

## CROSSWELL IMAGING AT THE WEYBURN FIELD FOR CO<sub>2</sub> TRACKING

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### RESEARCH OBJECTIVES

This work is an integral part of a comprehensive time-lapse seismic-monitoring program for monitoring a massive CO<sub>2</sub> flood in a thin, fractured carbonate reservoir in PanCanadian's Weyburn field, located at Williston Basin in southeast Saskatchewan, Canada. The goals of the project are to deploy technology that could track the detailed changes in CO<sub>2</sub> content as a function of time and to validate the monitoring capability of the surface seismic data (3-C and 9-C 3D) and 3D vertical seismic profiling (VSP), which were collected at the same time.

### APPROACH

In September 2000, Pan Canadian started the first phase of an extensive long-term CO<sub>2</sub>-miscible injection at its Weyburn field, located at Williston Basin. The flooding project is expected to expand over the field area for many years. To determine the applicability as well as refine the borehole methods, we carried out a comprehensive plan for using geophysical methods for

provide the proper scaling relationships for understanding overall flow behavior of the CO<sub>2</sub> fluid at reservoir dimensions. Addressed will be the trade-off between the spatial resolution and the spatial coverage of surface methods and borehole methods, respectively.

### ACCOMPLISHMENTS

A baseline horizontal crosswell-seismic survey was successfully acquired in August 2000 prior to the injection. To accomplish the goals in a cost-effective manner and within a production-constrained time window, we combined coiled-tubing deployment of a piezoelectric source with a 48-level hydrophone string in two parallel horizontal wells. The raw data recorded exhibit a wave field rich in many useful wave modes, including compressional, shear, and guided waves. A schematic of the geometry is displayed in Figure 1. The acquisition was performed as follows: The source was activated with a sweep of 200 to 2000 Hz every 3

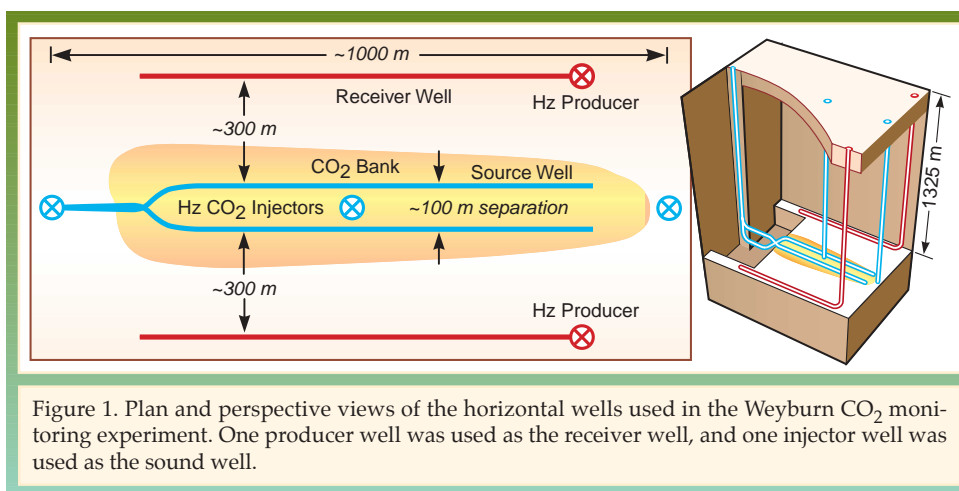


Figure 1. Plan and perspective views of the horizontal wells used in the Weyburn CO<sub>2</sub> monitoring experiment. One producer well was used as the receiver well, and one injector well was used as the sound well.

mapping fluid migration and dynamics. In addition to the baseline 3-C 3D VSP and surface-seismic surveys acquired by PanCanadian, Colorado School of Mines Reservoir Characterization Project's (CSM/RCP) on-going efforts in 9-C 3D surface seismic and VSP are being augmented with Berkeley Lab's high-resolution crosswell and Schlumberger's single-well efforts. The higher-resolution borehole data will be integrated with the surface seismic to provide an overall understanding of reservoir definition and the dynamics of fluid migration. The crosswell seismic is intended to provide tomographic images of changes in reservoir properties at a meter scale, or less. When integrated with the surface seismic and VSP, these data will

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